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Shared brain areas underlying imagined and perceived self-motion

Cognitive and Motor Functions of the Vestibular System Workshop

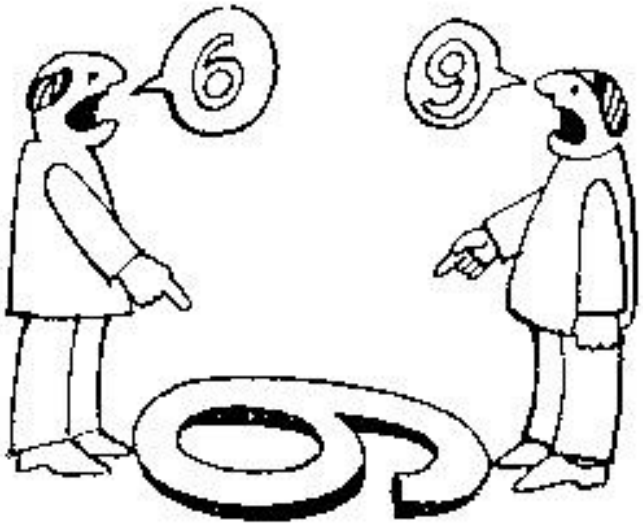
Aix-Marseille Université, Marseille

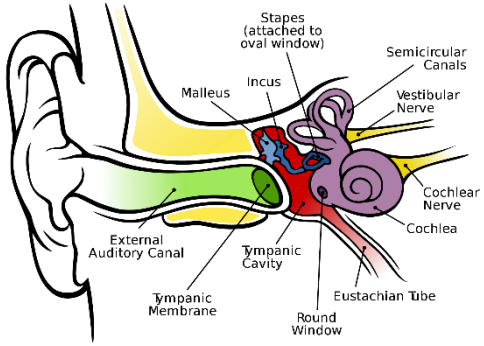
5-6th July 2018

Gianluca Macauda

Department of Psychology, University of Bern

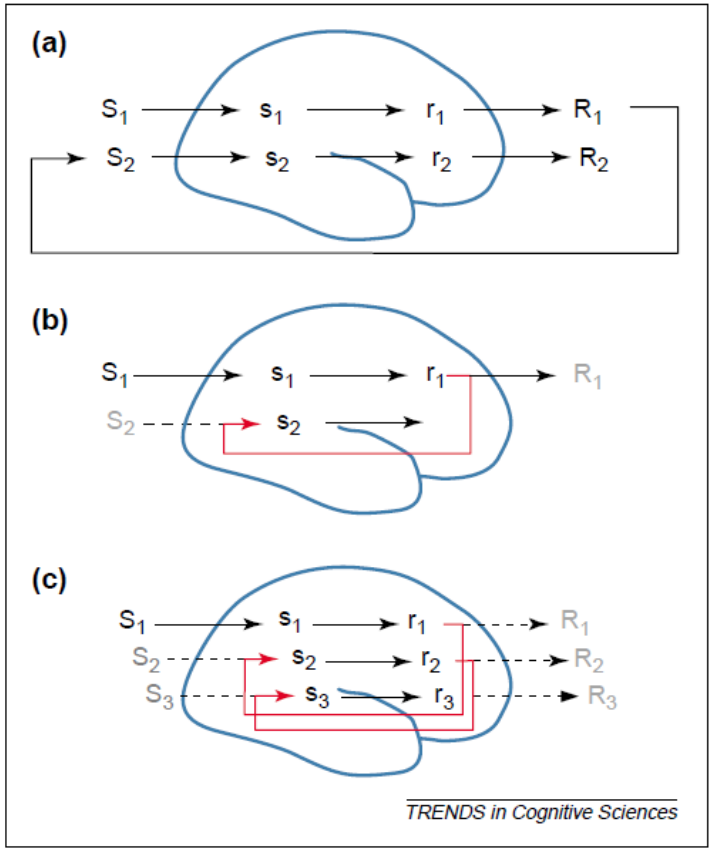
Mental changes of self location





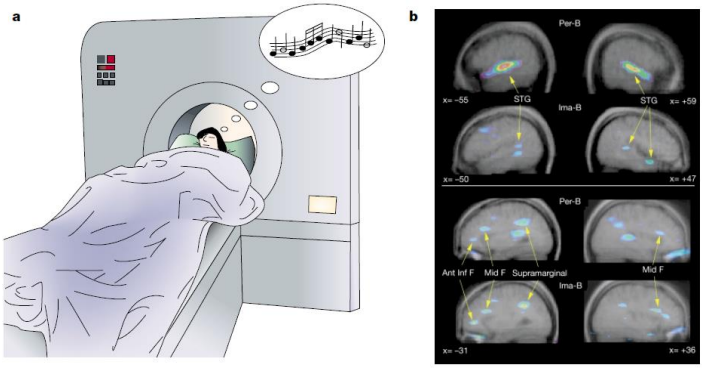
Mental Simulations & Neural Correlates

Idea

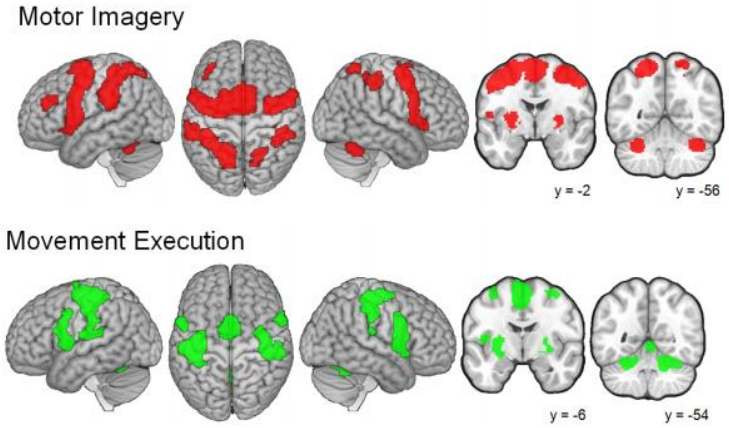


Hesslow, 2002

Neural Level



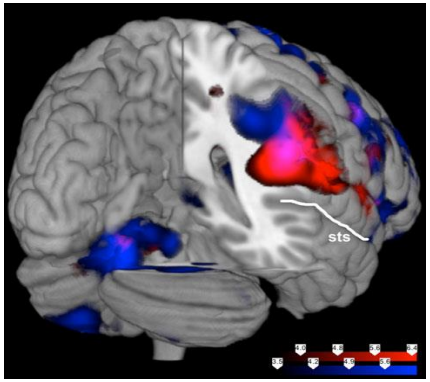
Kosslyn et al., 2001



Hardwick et al., 2017, bioRxiv

Vestibular imagery?

Vestibular Recall & Imagery



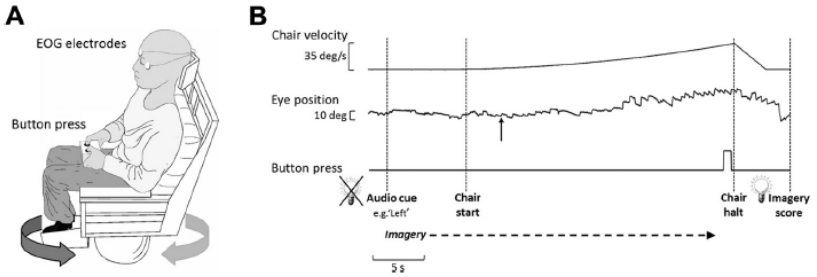
No vestibular areas involved in recall

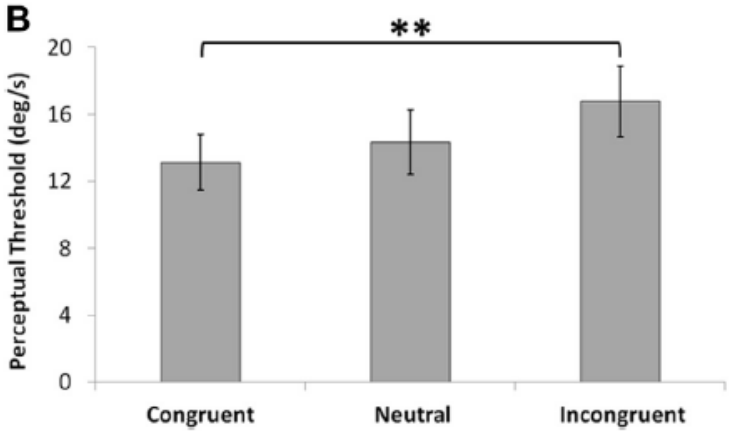
In contrast to the galvanic vestibular control experiment, we did not detect activations in the parietal operculum, the posterior insula (PIVC) or the superior temporal gyri. Other essential gateways within the cortical vestibular network like the hippocampus or the dorsolateral thalamus were also unresponsive during our vestibular recall task (Dieterich et al. 2005; Smith et al. 2010). All of which are well-known

Very difficult

cause the rating (Logie et al. 2011). Hence, we feel that the high degrees of difficulty in recalling a vestibular sensation and the missing activation of core regions within the vestibular network during the recall task suggest a hindered voluntary access to cortical vestibular areas.

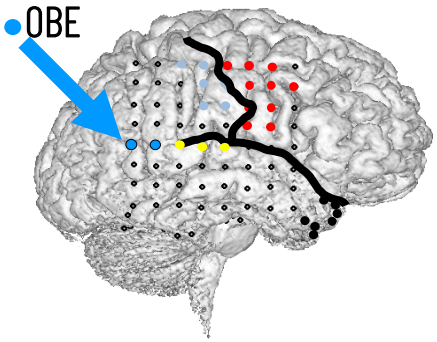
Zu Eulenburg et al., 2013





Nigamatullina et al., 2015

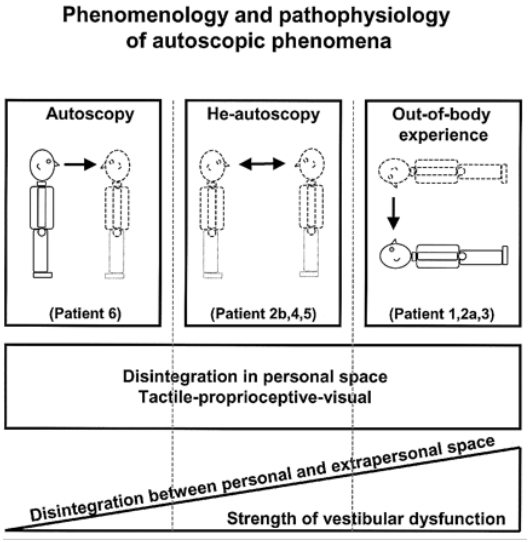
Why is this relevant?



Falling (2.5-3.0 mA)

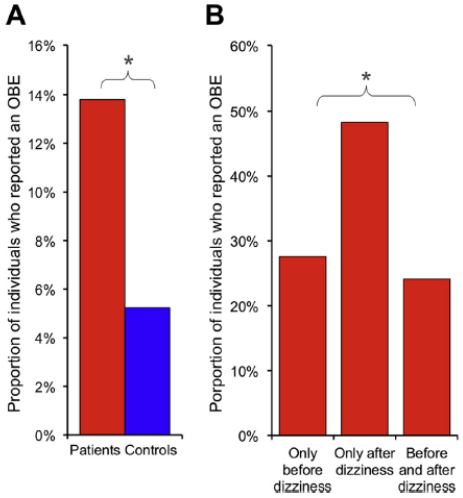
OBE (3.5 mA)

Blanke et al., 2002



Blanke et al. 2004

OBE in vestibular disorders



Lopez & Elzière, 2017

Mental self-rotation & Vestibular proccessing

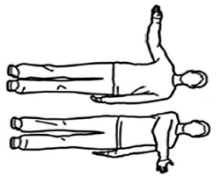
Idea: Areas involved in self-motion are also involved in simulated self-motion

Microgravity

Grabherr et al. 2007

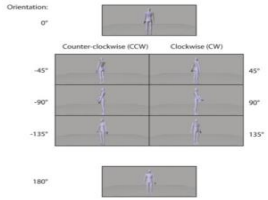
GVS

Lenggenhager et al. 2008
Dilda et al., 2011



CVS

Falconer & Mast, 2012



Passive self-motion

Van Elk & Blanke, 2014
Deroualle et al., 2015

➔Mental body transformations

(simulated change in self-location)

Inconclusive results: Conflicting stimulations, Individual strategies

Galvanic Vestibular Stimulation and Mental Rotation

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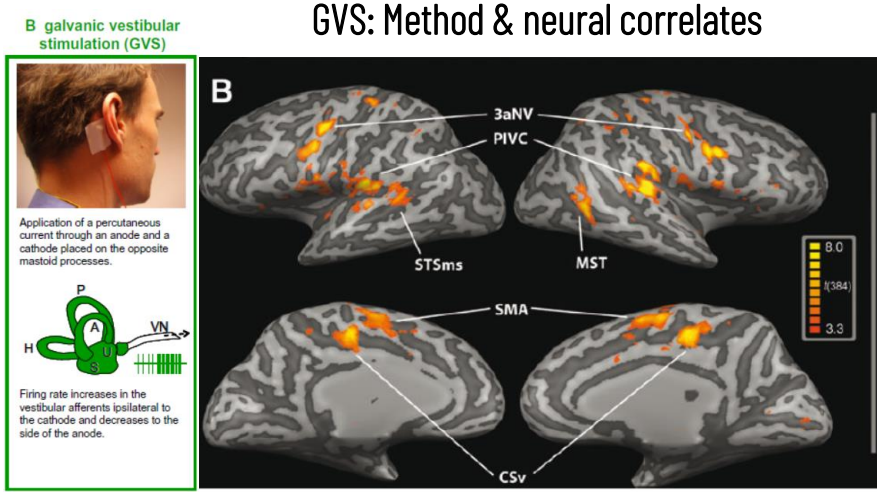
Which cortical areas are involved in vestibular processing and simulated self-location changes?

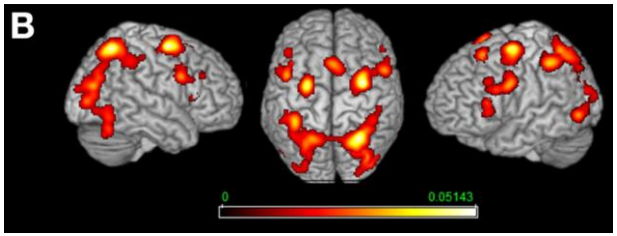
GVS: Method & neural correlates



Lopez et al., 2012

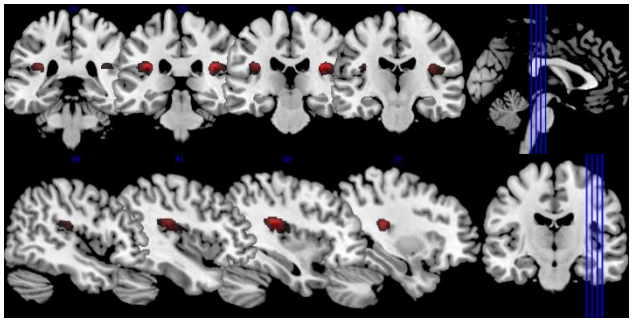
Smith et al., 2012

Mental Rotations



Tomasino et al., 2016

Area OP2



Eickhoff et al., 2006

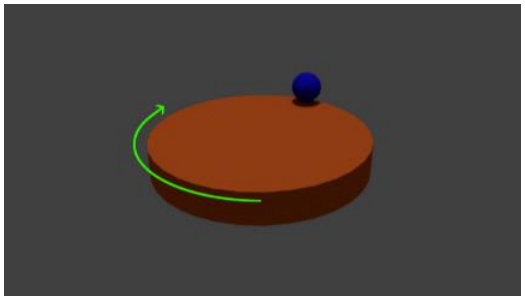
Current study: Two aims

1. Cortical overlap of *simulated* and *perceived* self-motion
   - Simulated = egocentric mental rotation
   - Perceived = GVS

2. Behavioral effects of GVS on simulated self-motion

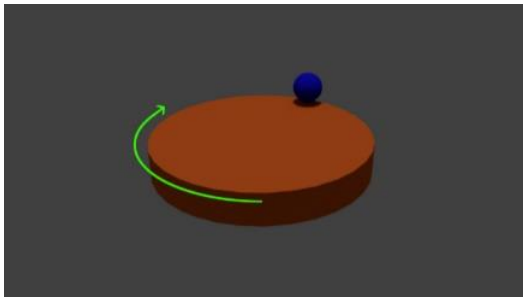
Mental Rotation & Vestibular Stimulation

Egocentric Rotation



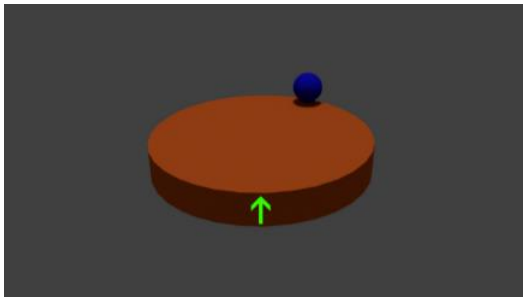
Left

Object Rotation



Right

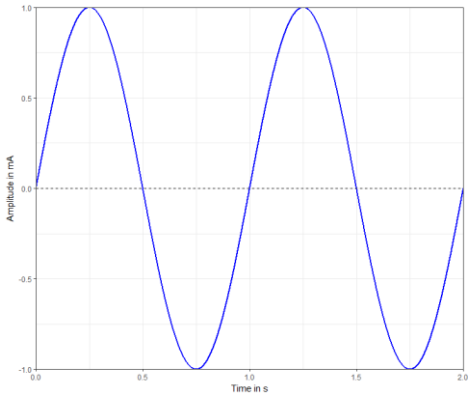
No Rotation



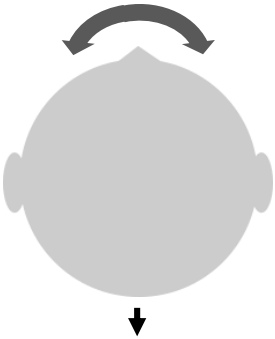
Right

Keehner et al., 2006

GVS Signal

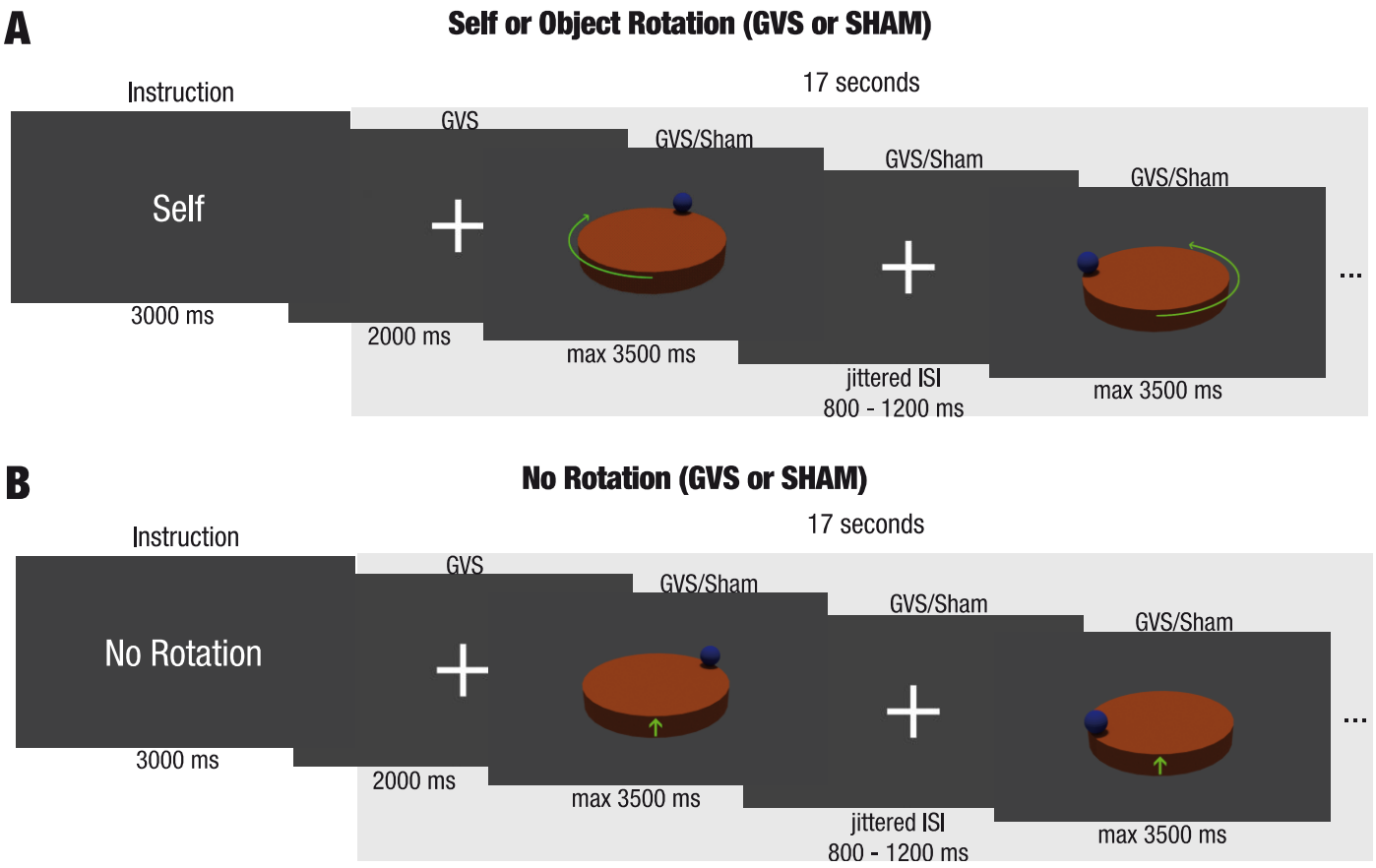


Sensation



Gravity

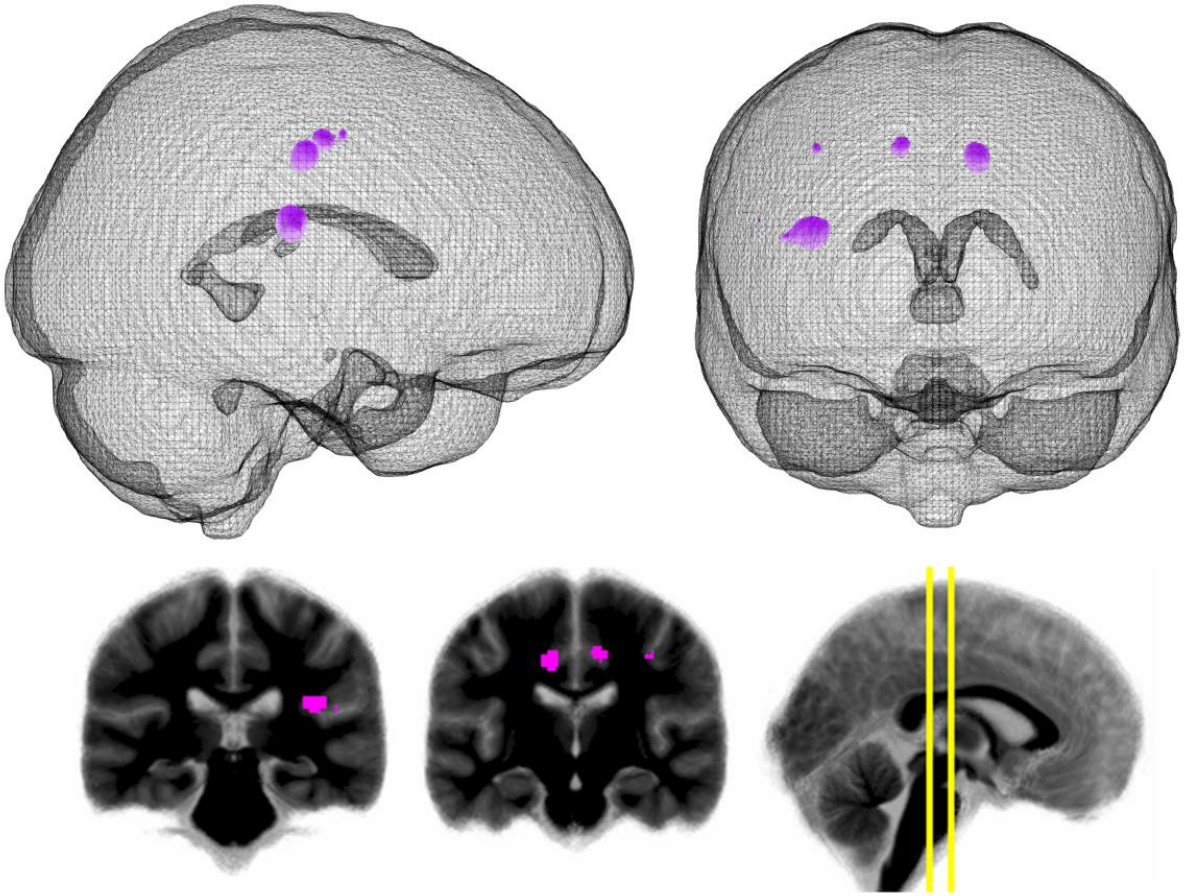
fMRI Design



3 (Egocentric, Object, No Rotation) x 2 (GVS, Sham) Design

Main effect of GVS

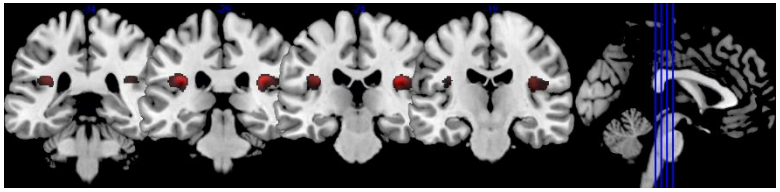
GVS vs Sham over all rotation tasks



pFWE < 0.05

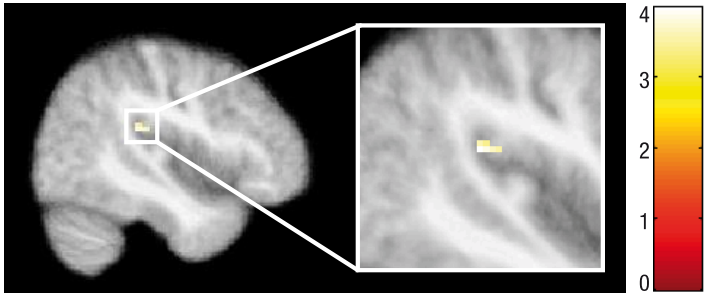
Conjunction analysis: Area OP2 I

Area OP2



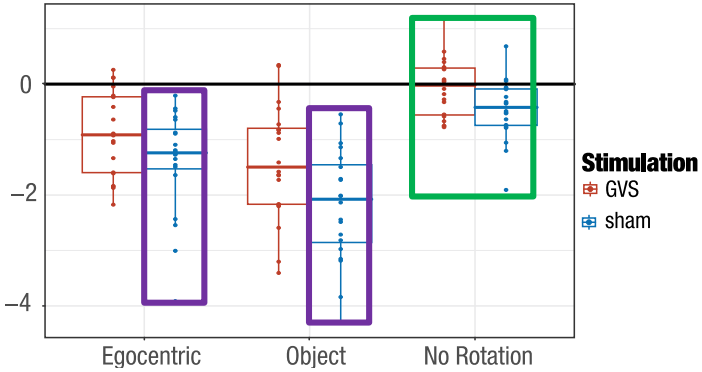
Vestibular processing & egocentric mental rotation

A) Conjunction egoncentric rotation & vestibular processing in OP2



pFWE-SVC = .039

B) Mean parameter estimates from conjunction in OP2



Current study: Two aims

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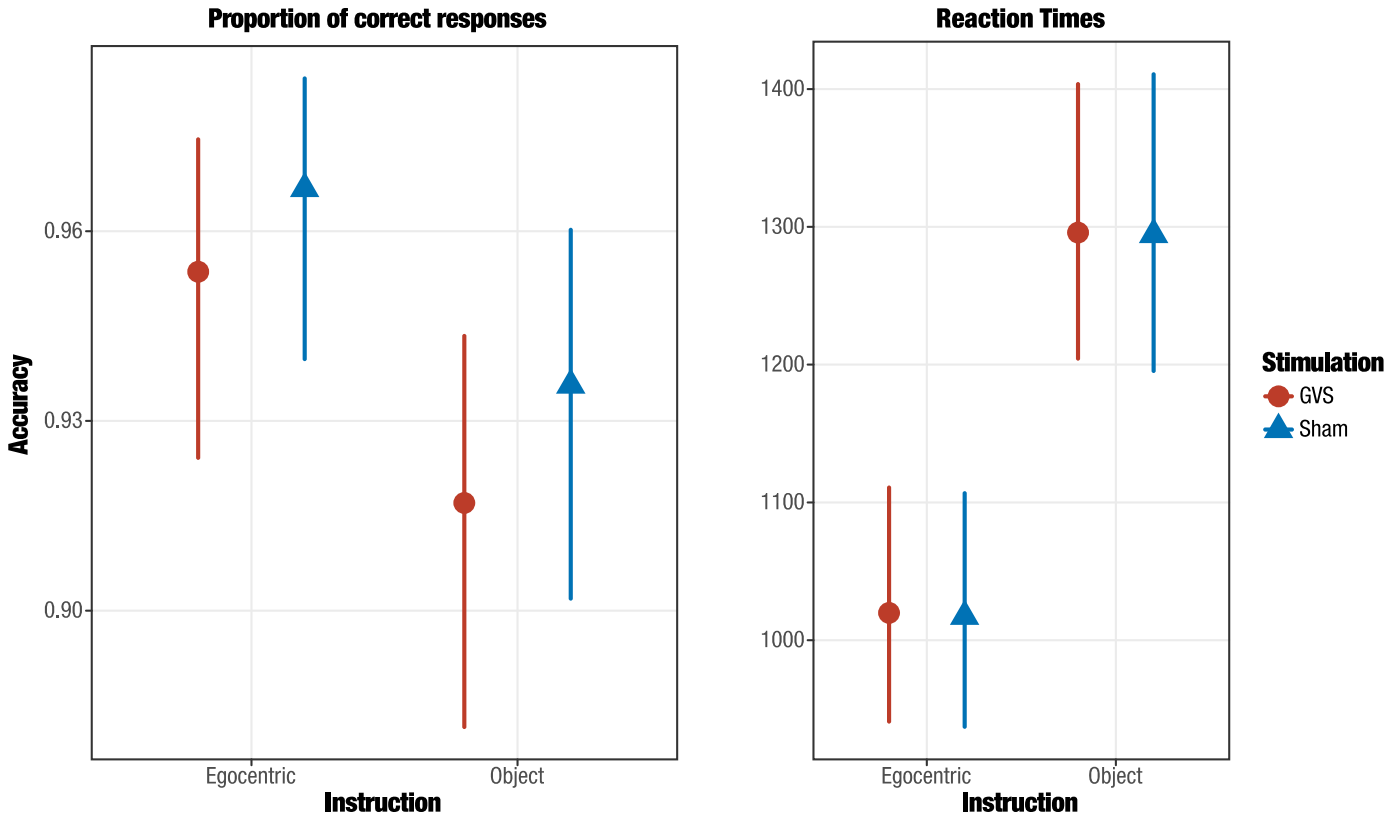
Accuracy & Reaction Times



Conclusion

> Vestibular brain areas are involved in egocentric mental rotation.

> First evidence that *vestibular processing* and *egocentric mental rotation* rely on shared area in the vestibular cortex (area OP2)

> No effect of GVS on egocentric mental rotation
  - Robustness to interference?
  - Task difficulty?
  - Difference to body rotation task?

Acknowledgment

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Bigna Lenggenhager (Department of Psychology, University of Zurich)

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Thank you for the attention

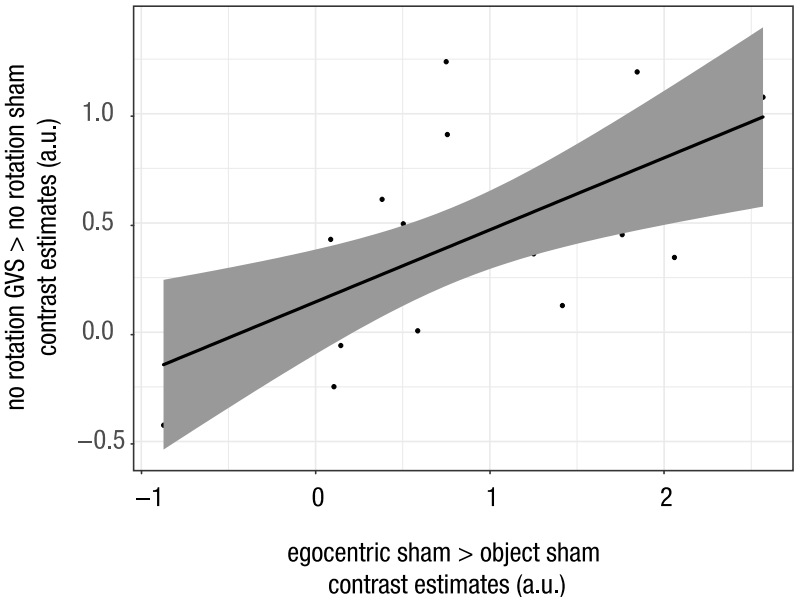
Conjunction analysis: Area OP2 II

Post hoc correlations

Shared area involved in egocentric mental rotation and vestibular processing

Brain-Behavior relationship: The higher the difference, the faster the responses

C) Contrast estimates OP2 conjunction



D) Contrast estimates & Reaction Times – OP2 conjunction